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(54) Variable length coding

(57) A block of data is runlength coded into a symbol having a variable number of run bits. Initially, the number of run bits is set at the number of bits required to represent the length of the block. However, since the block is of finite size, the maximum potential runlength decreases each time a runlength code is generated. Therefore, the number of bits used for the runlength code is successively reduced as the maximum potential runlength decreases.

This coding regime may be used adaptively as an alternative to Huffman coding based on the characteristics of the input data block.

FIG. 5

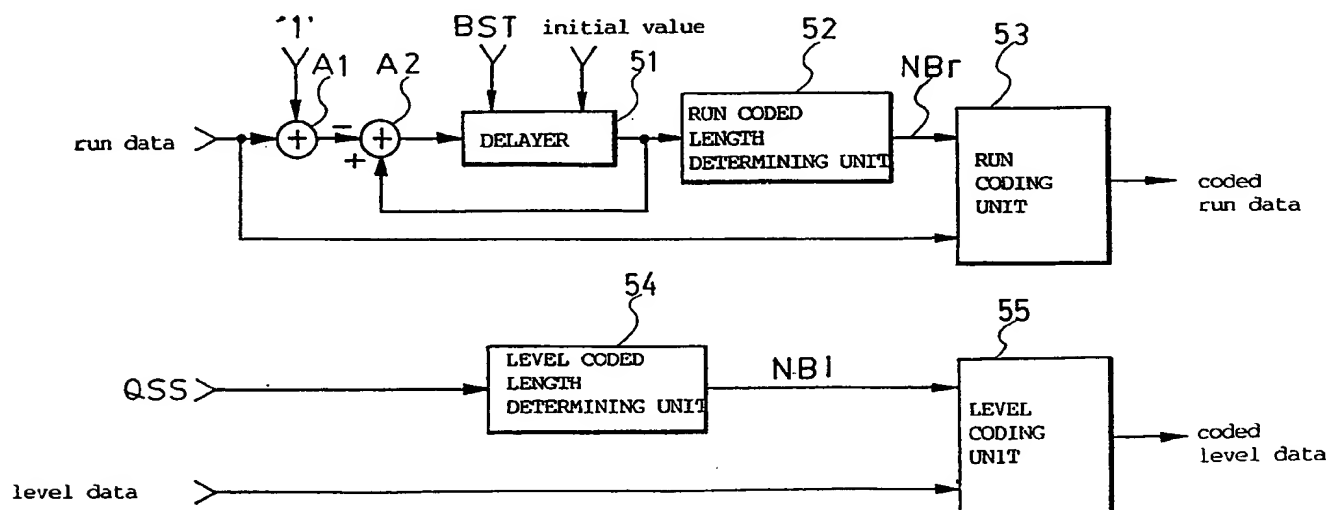


FIG. 1
PRIOR ART

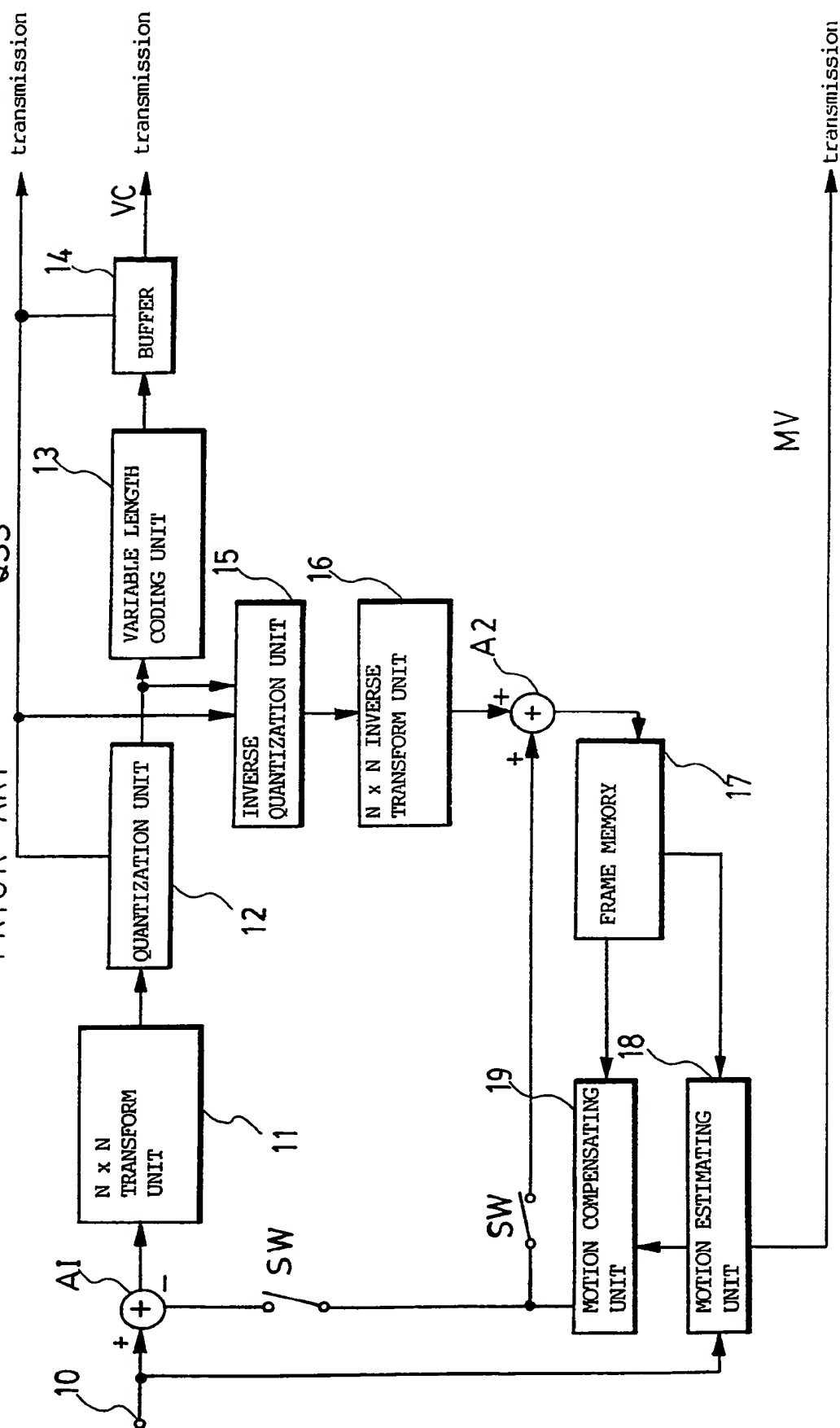


FIG. 2
PRIOR ART

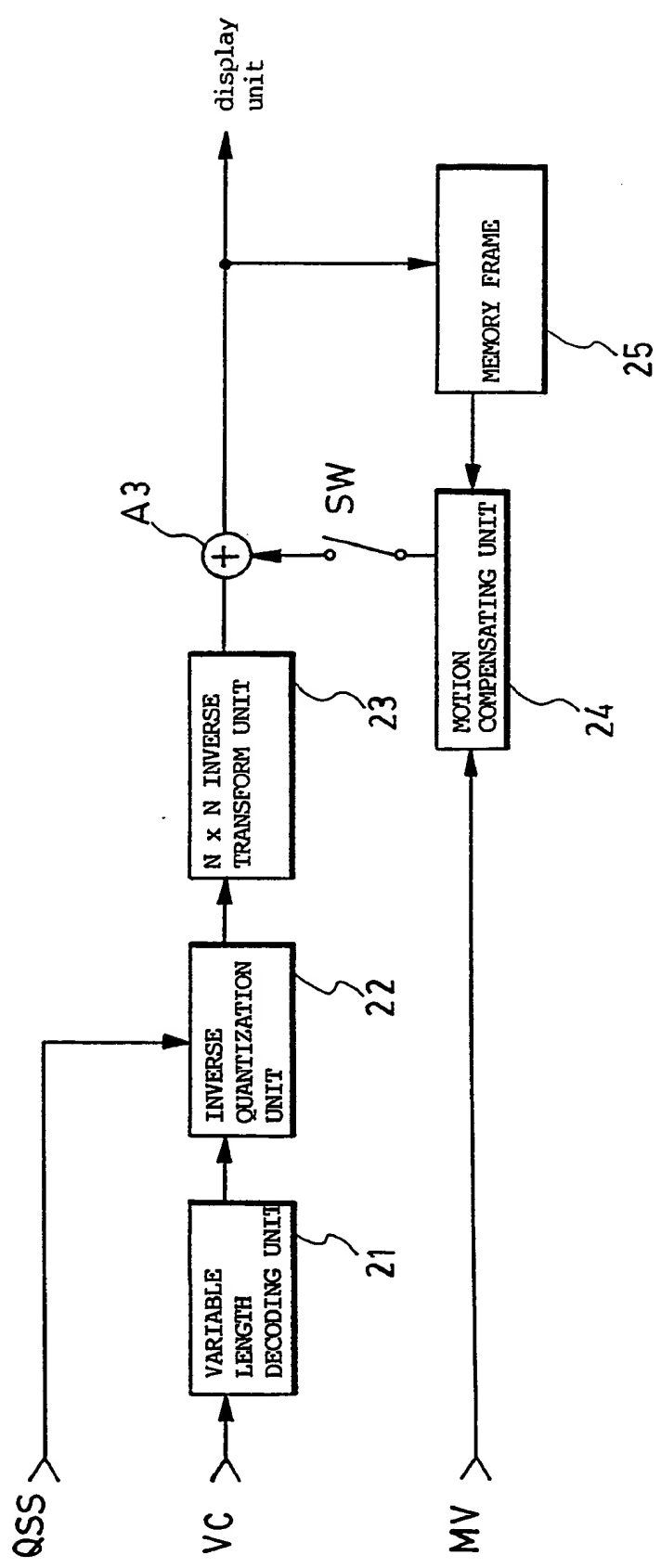


FIG. 3A
PRIOR ART

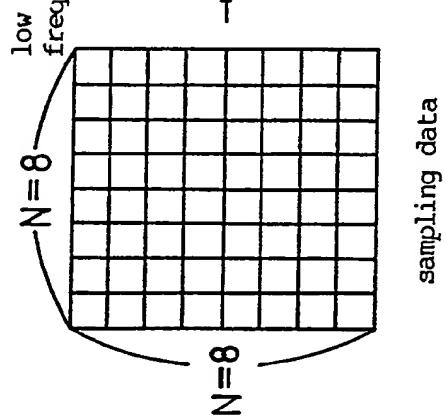


FIG. 3B
PRIOR ART

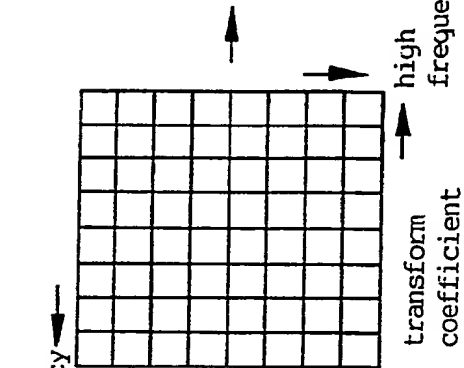


FIG. 3C
PRIOR ART

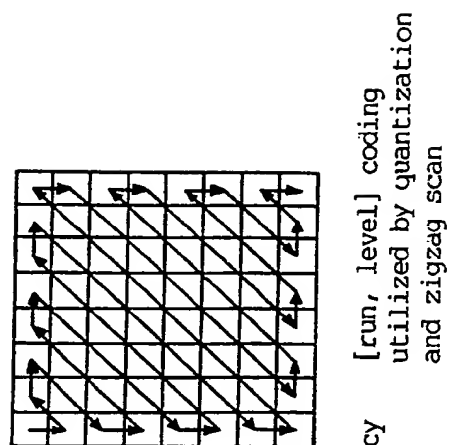


FIG. 4
PRIOR ART

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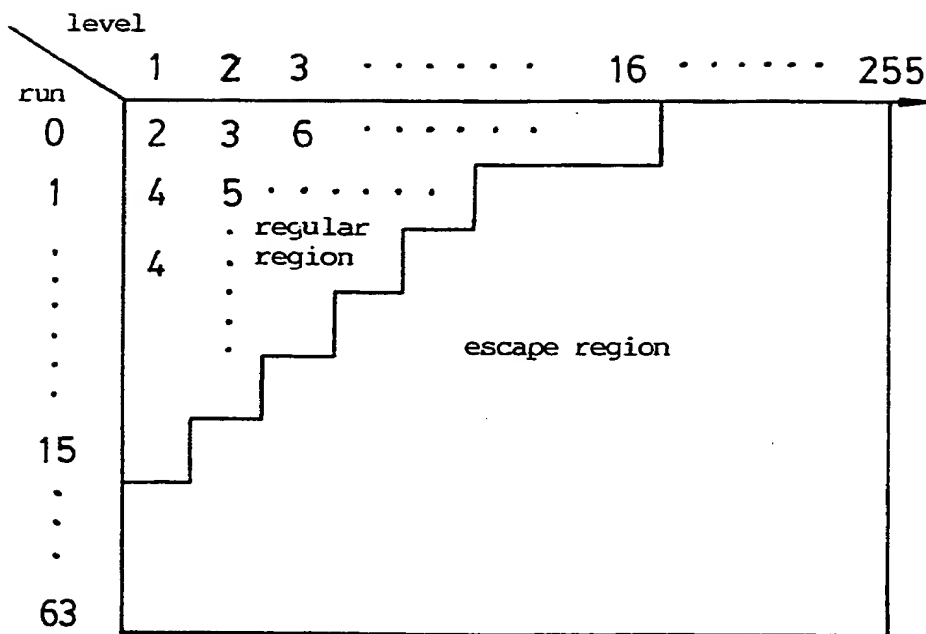


FIG. 5

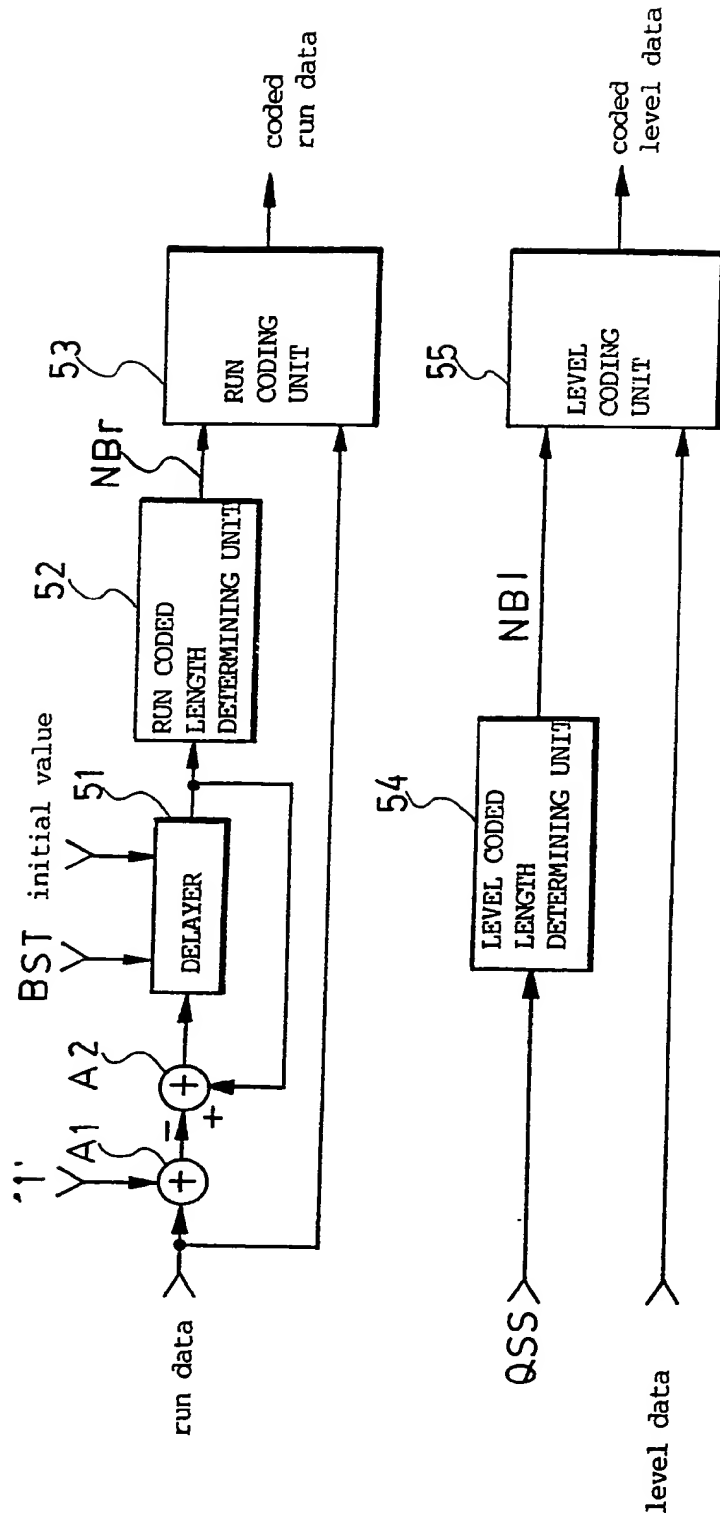


FIG. 6

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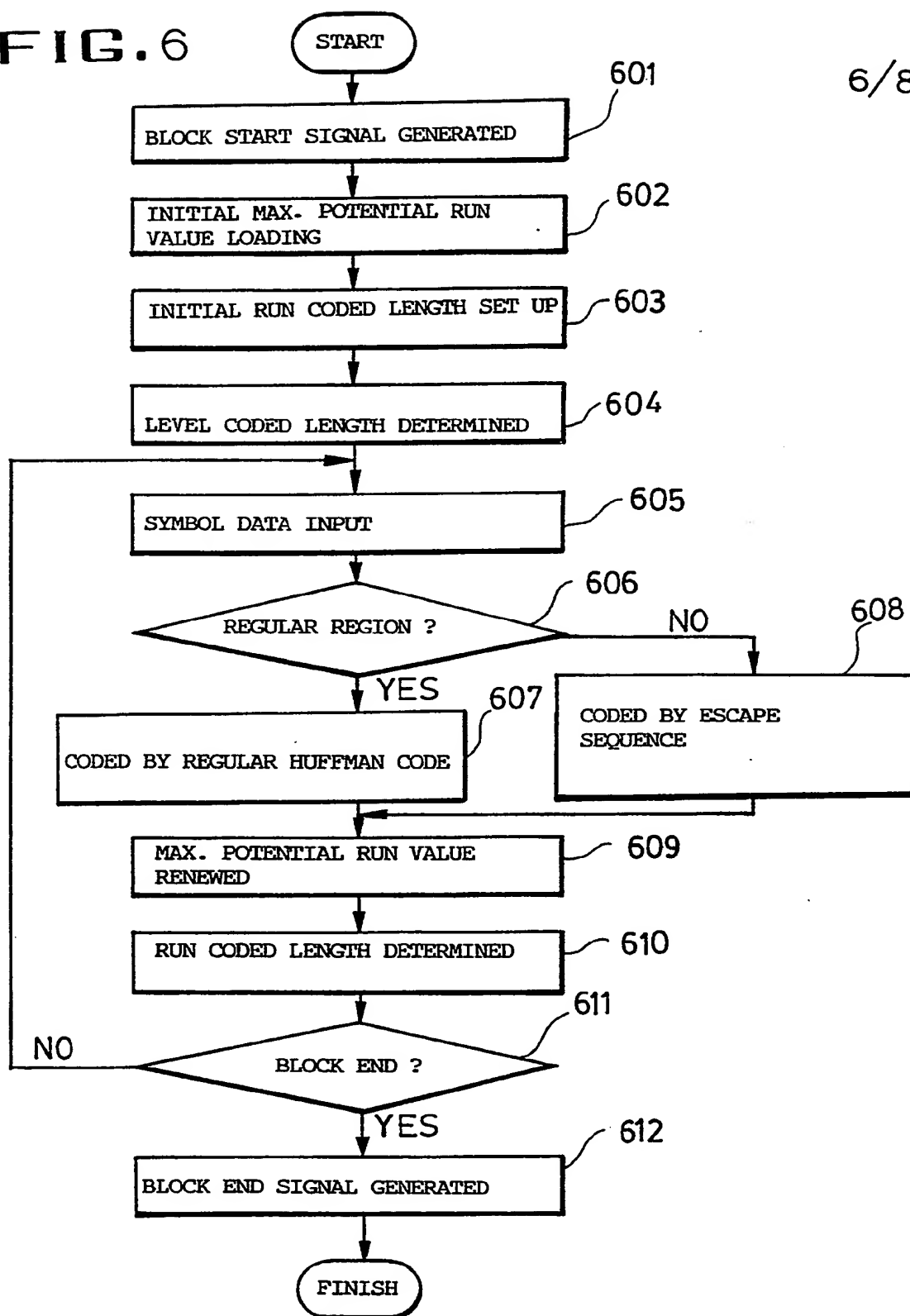


FIG. 7

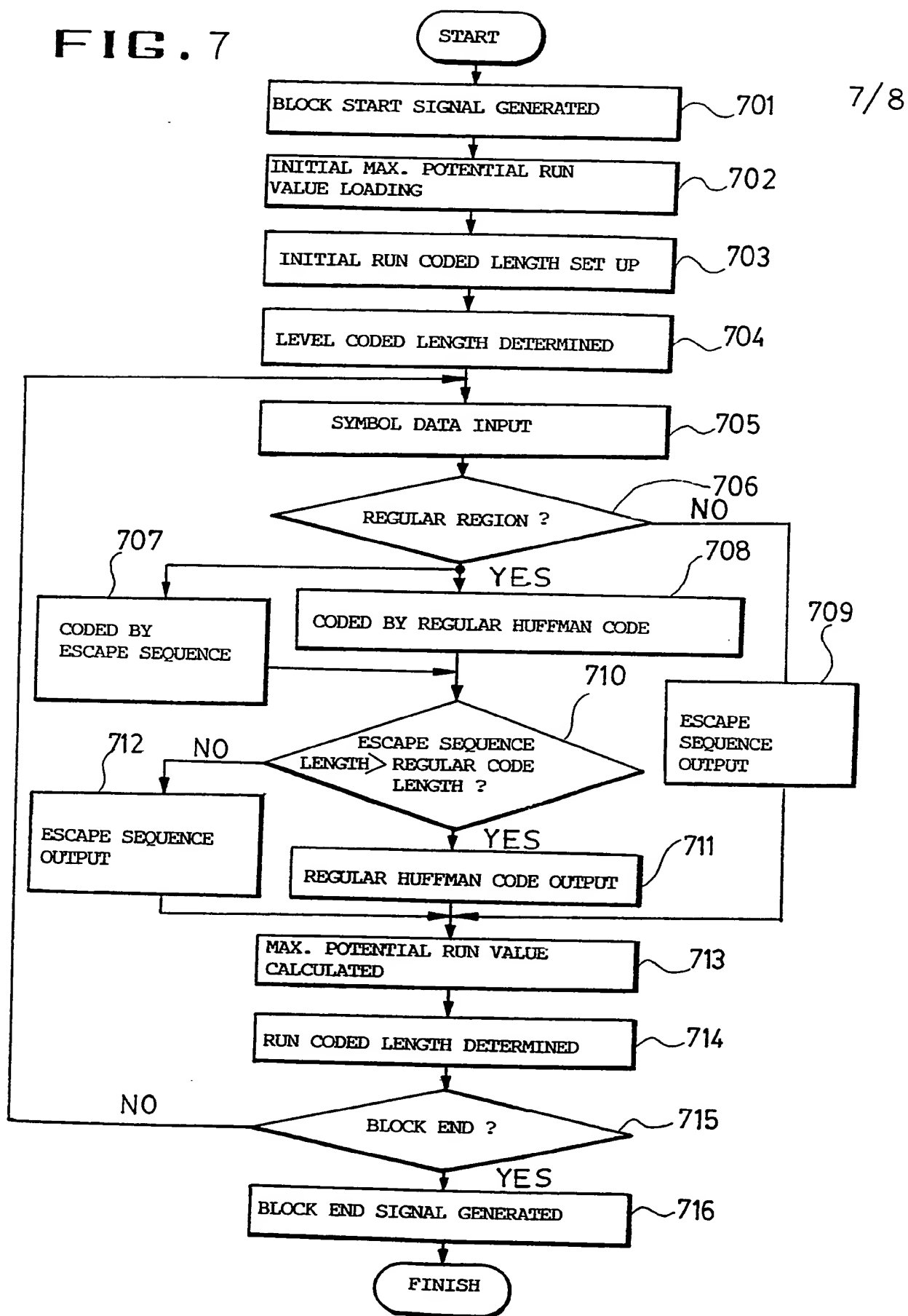
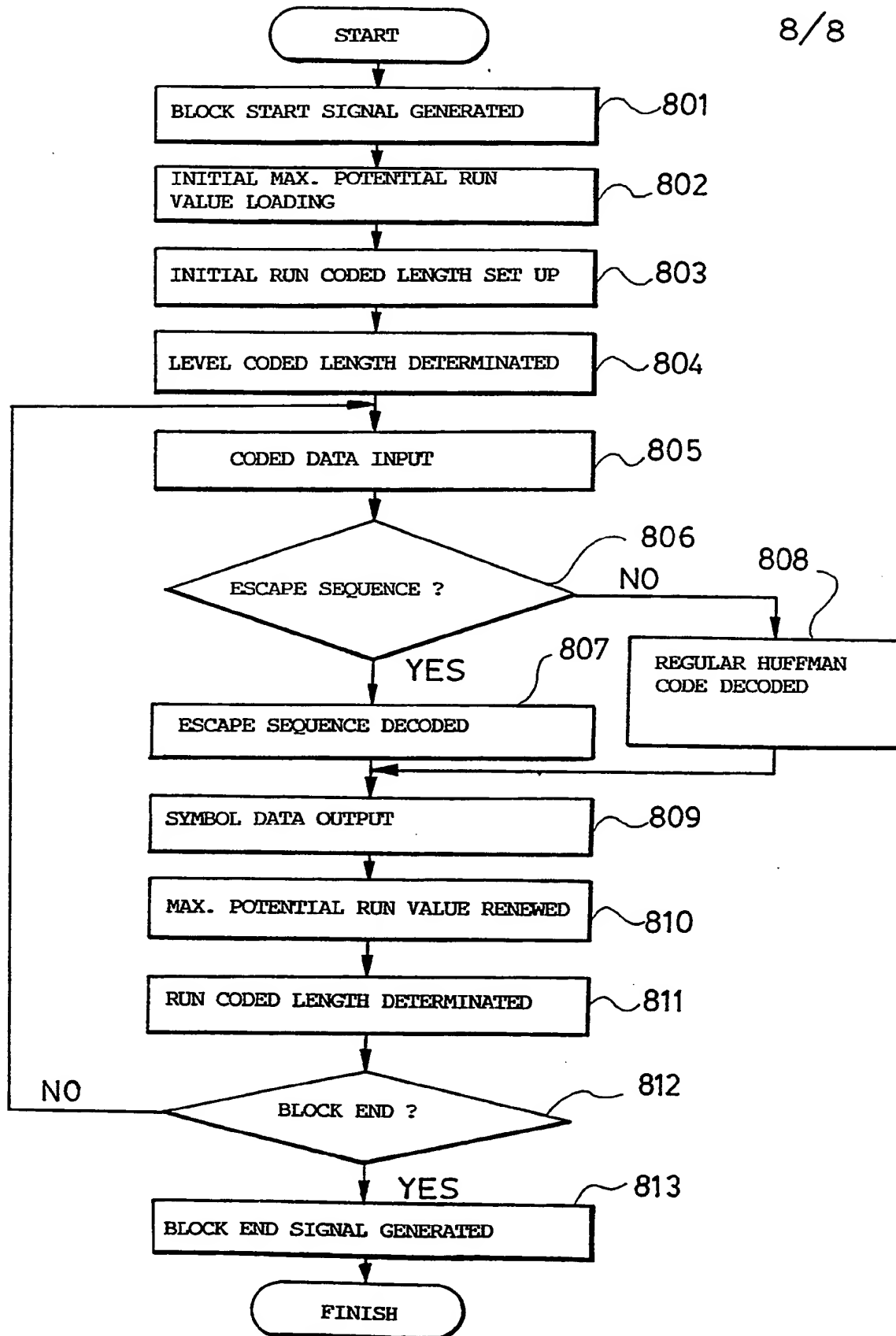


FIG. 8

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VARIABLE LENGTH CODING METHOD & APPARATUS

DESCRIPTION

5

The present invention relates to a method and apparatus for variable length coding. It also relates to a method of decoding a signal coded according to the present invention. The present invention has particular, though not exclusive, application to the transmission of video images.

15

In order to improve picture quality, it has recently become popular to encode video image signals and process them as digital data. However, a large amount of digital data is required to represent a video signal. Therefore, transform coding, differential pulse code modulation (DPCM), vector quantization, variable length coding and the like are performed in order to reduce the amount of data required by removing redundant data contained in the digital video image signal.

20

Figure 1 is a block diagram illustrating a conventional coding apparatus. The apparatus comprises means for performing a transformation by discrete cosine transformation (DCT) on an $N \times N$ block of data to produce quantized transform coefficients; means for performing variable length coding on the quantized data to thereby compress substantially the data; and means for performing inverse quantization and inverse transformation of the quantized data so that motion compensation may be performed.

In Figure 1, the image signal input through an input terminal 10 is transformed into a signal in the frequency domain in $N \times N$ blocks by an $N \times N$ transform unit 11 and the energy of spectrum represented by the coefficients produced is mainly contained in the low frequency components. A data transform on each block is performed by methods such as a DCT, Walsh-Hadamard Transformation WHT, Discrete Fourier Transformation DFT, Discrete Sine Transformation and the like.

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A quantization unit 12 transforms the transform coefficients to representative values of certain levels through a predetermined quantization process. A variable length coding unit 13 makes the most of statistical characteristics of the representative values to thereby perform the variable length coding, so that the data can be markedly compressed.

In accordance with the state of a buffer 14, where variable-length-coded data is stored, a transformed quantization step size Qss controls the quantization unit to thereby adjust a transmission bit ratio. The quantization step size Qss can be transmitted to a receiving station to be utilized by a decoding apparatus. Furthermore, because there are usually many similar portions in successive screens even in the case of a screen filled with a motion, the motion is estimated to calculate a vector thereof, and if data is compensated by utilizing the vector, and because a signal representing the difference between neighbouring screens has a relatively low information content, the transmitted data can be substantially compressed.

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In order to perform motion compensation, an inverse quantization unit 15 and an $N \times N$ inverse transform unit 16 are provided, as shown, in Figure 1 to perform inverse quantization on the quantized data, output from the quantization unit 12, so that it can be transformed to an image signal in the space domain.

The image signal output from the inverse transform unit 16 is stored per frame unit in a frame memory 17 and a motion estimating unit seeks a block pattern most similar to the $N \times N$ block data of the input terminal 10 from the frame data stored in the frame memory 17 to thereby calculate a motion vector MV , representing the relative motion between the two blocks. The motion vector is transmitted to the receiving station to be utilized by a decoding apparatus and at the same time to a motion compensating unit 19.

The motion compensating unit 19 receives the motion vector MV from a motion estimating unit 18 and reads out an $N \times N$ block corresponding to the motion vector MV from the preceding frame's data output from the frame

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memory 17 to thereby supply the same to an adder A1 connected to the input terminal 10.

5 Then, the adder A1 calculates a difference between an N x N block supplied to the input terminal 10 and an N x N block of similar pattern supplied from the motion compensating unit 19, and the output data of the adder A1 is coded for transmission to the receiving station.

10 In other words, at first, the signals for the whole image are transmitted and then only a difference signal is transmitted.

15 The data whose motion has been compensated at the motion compensating unit 19 is added to the image signal output from an adder A2 to the NxN inverse transform unit 16 to thereafter be stored in the frame memory 17.

20 A refresh switch (not shown) is occasionally opened by a control means, and because the input image signal is coded by Pulse-Count Modulation PCM for transmission, only the difference signal is coded, so that an

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accumulation of codes resulting from the transmission
can be refreshed in a predetermined time interval and a
transmission error on a channel can be removed at the
receiving station within a predetermined period of
5 time.

In this manner, the coded image data is transmitted to
the receiving station to be input into the decoding
apparatus as indicated in Figure 2.

10

The coded image data is decoded by a variable length
decoding unit 21 by means of an inverse coding process.
The data output from the variable length decoding unit
21 is inversely quantized at an inverse quantization
15 unit 22. At this moment, in the inverse quantization
unit 22, the magnitude of an output transform
coefficient is adjusted by the quantization step size
Qss supplied from the coding apparatus. An NxN inverse
transform unit 23 transforms frequency domain transform
20 coefficient, supplied from the inverse quantization
unit 22, into image data in the space domain.
Furthermore, the motion vector MV transmitted from the
coding apparatus, as illustrated in Figure 1, is

supplied to a motion compensating unit 24 of the decoding apparatus, which reads out an $N \times N$ block corresponding to the motion vector MV from a frame data stored on a frame memory 25 to thereafter compensate
5 for the motion of the image and to thereby supply the compensated image data to an adder A3.

The adder A3 adds inversely transformed DPCM data to an $N \times N$ block of data, supplied from the motion
10 compensating unit 24 and outputs a result to a display unit.

Figures 3A-3C are schematic drawings illustrating a quantization process for image data. Sampled image
15 data in an $N \times N$ block, as indicated in Figure 3A, is transformed to a set of transform coefficients in the frequency domain as illustrated in Figure 3B by DCT or the like.

20 After the transform coefficients are quantized, they are scanned in a zig-zag manner as illustrated in Figure 3C for coding in a [run, level] manner. When the $N \times N$ block is scanned, a low frequency component is

started with, as illustrated in Figure 3C, and then a high frequency component is scanned for coding as a "run" and "level" pair.

5 Here, the "run" corresponds to a number of "0" existing among the coefficients which are not "0" among the quantized coefficients of the NxN block and the "level" corresponds to an absolute value of the coefficients which are not "0". By way of example, in the case of
10 an 8 x 8 block, the "run" can have a value ranging from "0" to "63". The "level" varies according to a data value output from the quantization unit. For example, if a quantization output value is expressed as an integer from "-255" to "+255", the "level" comes to
15 have a value from "1" to "255". The reference symbols, "+" or "-" are expressed by separate sign bits.

As seen from the foregoing, if [Run, Level] is utilized as a symbol, and if the Run is large or Level is large,
20 the frequency of occurrence of the symbols is very low statistically. Accordingly, as illustrated in Figure 4, a regular region and an "escape" region are partitioned according to the frequency of occurrence of

the symbols so that a Huffman code is utilized to code the image data for the regular region where the frequency of occurrence is relatively high, and the image data is coded utilizing the escape sequence for the escape region where the frequency of occurrence is low.

The Huffman code allocates a short-length code when the frequency of occurrence of a symbol is high and a long-length code when the frequency of occurrence of a symbol is low. The escape sequence, which has coded data from the escape region, comprises an escape code ESC, run, level and sign data. Each element having respective predetermined numbers of bits as indicated in the following:

$$\text{Escape Sequence} = \text{ESC} + \text{RUN} + \text{L} + \text{S} \dots\dots\dots (1)$$

For example, when a quantized value in the 8 x 8 block ranges "from -255 to 255", the escape sequence has an escape code of 6-bits, run data of 6-bits, level data L of 8-bits and sign data S of 1-bit, totalling a fixed 21-bits.

In this way, in a conventional variable length coding method, various additional information is transmitted along with coded data and, furthermore, because the escape data has a predetermined fixed length, there has
5 been a limit to the compression of the transmitted data.

It is an aim of the present invention to overcome the aforementioned disadvantages of the prior art.

10

According to a first aspect of the present invention, there is provided a variable length coding method comprising the steps of:

- (a) storing a maximum potential runlength;
- 15 (b) producing a runlength signal, having the number of bits required for the stored maximum potential run length, from an input run data signal;
- (c) producing a new maximum potential runlength by subtracting the run data and a predetermined
20 factor from the current maximum potential runlength;
- (d) storing the new maximum potential runlength; and
- (e) repeating steps (a), (b), (c) and (d).

Preferably, the method further comprises the steps of:

(f) determining the number of bits required to represent a level signal based on a quantization step signal; and

5 (g) producing a level signal having a number of bits determined in step (f).

According to a second aspect of the present invention, there is provided a variable length coding method comprising the steps of:

10 (a) determining whether an input signal belongs to a first predetermined set or a second predetermined set; and
(b) if the input signal belongs to the second
15 predetermined set, coding it according to the first aspect of the present invention.

Preferably, the second aspect of the present invention further includes the step of:

20 (c) if the input signal belongs to the first predetermined set, coding it according to Huffman coding.

More preferably, it includes the steps of:

- (d) if the input signal belongs to the first set, coding it according to the first aspect of the present invention; and
- 5 (e) comparing the lengths of the codes produced at steps (c) and (d) and transmitting the coded signal having the shorter length.

According to a third aspect of the present invention,
10 there is provided a variable length coding apparatus comprising: storage means for storing a maximum potential runlength; input means to input a run data signal; coding means responsive to the bit length of a maximum potential runlength stored in the storage means
15 to output the data of the run data signal as a runlength signal having the same number of bits as the stored maximum potential runlength; and means to generate a new potential maximum runlength in dependence on the input run data signal and the stored
20 maximum runlength.

Preferably, the storage means comprises a delay.

Preferably, the means to generate a new potential
maximum runlength comprises a first adder for adding 1
5 to the input run data and a second adder for
subtracting the output of the first adder from the
stored maximum potential runlength.

Preferably, the apparatus includes means responsive to
10 a quantization step size signal to produce a level
signal having a length in bits determined by said
quantization step.

According to a fourth aspect of the present invention,
15 there is provided a variable length coded signal
decoding method comprising the steps of:

- (a) determining the number of bits of a symbol of an
input signal which convey runlength data;
- (b) decoding said runlength data;
- 20 (c) decoding level data of said symbol; and
- (d) producing an output signal in dependence on the
decoded runlength data and the decoded level
data.

Preferably, the method further comprises the steps of:

- (a) determining whether an input signal is a signal according to a Huffman code or a signal generated according to claim 1 or 2; and
- 5 (b) decoding the input signal in response to the result of step (a).

Embodiments of the present invention will now be described, by way of example, with reference to Figures
10 5 to 8 of the accompanying drawings, in which:

Figure 1 is a block diagram of an embodiment of a conventional image data coding apparatus;

15 Figure 2 is a block diagram of an embodiment of a conventional image data decoding apparatus;

Figures 3A-3C are schematic drawings illustrating a quantization process for image data;

20 Figure 4 is a region diagram in accordance with the frequency of occurrence of a symbol during two-dimensional Huffman coding;

Figure 5 is a block diagram illustrating a preferred embodiment of a variable length coding apparatus in accordance with the present invention;

5 Figure 6 is a flow chart of one embodiment of variable length coding method in accordance with the present invention;

10 Figure 7 is a flow chart of another embodiment of an improved variable length coding method in accordance with the present invention; and

15 Figure 8 is a flow chart of a preferred embodiment of a variable length coded data decoding method in accordance with the present invention.

20 The apparatus in Figure 5 comprises: a delay 51 which is loaded with a predetermined value when variable length coding on each block is started, and is supplied with the run value of a [run, level] symbol; a run coded length determining unit 52 for determining the number of bits NBr necessary for coding data in accordance with the maximum potential run value

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supplied from the delay 51; a run coding unit 53 for coding the run data in accordance with the bit number NBr determined by the run coded length determining unit 52; a level coded length determining unit 54 for determining a bit number NBl necessary for expressing a level value by receiving a quantization step size signal Qss; and a level coding unit 55 for coding the level data in accordance with the bit number NBl determined by the level coded length determining unit 54.

When variable length coding is started on each block, a block start signal BST is inputted to the delay 51 to load an initial value. By way of example, in the case of an 8 x 8 block, "63" is loaded into the delay 51.

When the [run, level] symbol is applied, the run data has "1" added to it by the first adder A1, and the result is then subtracted from the maximum potential run value stored in the delay 51 by the second adder A2. Subsequently, the delay 51 outputs the decreased new maximum potential run value.

The run coded length determining unit 52 determines the bit number NBr necessary for coding the run data in accordance with the maximum potential run value supplied from the delay 51. Then, the run coding unit
5 53 codes the run data in accordance with the bit number NBr determined by the run coded length determining unit 52.

The level coded length determining unit 54 determines
10 the bit number NB1 necessary for expressing the level in accordance with an incoming quantization step size. In other words, the number of values, which the quantization output can possess, can be determined when the maximum potential value of the transform
15 coefficient is divided by the quantization step size. For this, the bit number NB1 necessary for expressing the level is determined. Then, the level coding unit codes the level data in accordance with the bit number NB1 determined by the level coded length determining
20 unit 54.

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Assuming that the run value of the [run, level] symbol, supplied to the apparatus of Figure 5 is "000011" having 6-bits, and the level value is "00001010" having 8-bits, the run value of "000011" has 1 added to it by the first adder A1, and the second adder A2 subtracts the output of the first adder A1 from the current maximum potential run value. The result thereof is utilized in order to process the subsequent [run, level], and the run code length is determined for the currently-input run data, in accordance with the maximum potential run stored in the delay 51.

In other words, in the case of an 8 x 8 block, because the maximum potential "run" at the initial stage is "63", which is stored on the delay 51, the run coded length determining unit 52 determines the run coded length NBr as being 6-bits.

The "63" is input to the adder A2, and the run data input at this moment has "1" added to it by the adder A1, and is input to the adder A2 to be subtracted from the "63". The output of the adder A2 is input into the delay 51. In this way, the maximum potential "run"

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is decreased, so that the bit number representing the "run" is also decreased.

5 If the maximum potential run stored on the delay 51 is assumed to be "6", because "6" can be expressed in with 3-bits, the run coded length NBr and outputs the bit number NBr as "3". Then, the run coded unit 53 codes the "000011" of the run data as "011" in the 3-bit run data output.

10

Furthermore, if it is assumed that the quantization step size Qss, supplied to the level coded length determining unit 54, is a relatively large value and the number of potential quantized values is 50, then 50
15 quantized values can be expressed by 6-bits and the level coded length determining unit 54 determines 6-bits as the level coded length NB1 and outputs "6". Then, the level coded unit 55 codes the "00001010" of the level data as "001010" in the 6-bit level data
20 output.

Accordingly, because the run data in an escape sequence has a data length from "0-bits" to "6-bits" and the level data has a data length from "0-bits" to "8-bits", the escape sequence adds the escape code data of "6-bits", the run data from "0-bits" to "6-bits", the level data from "0-bits" to "8-bits" and "1-bit" of sign data to thereby make a variable length of "7-bits" to "21-bits".

10 In other words, the variable length corresponds to a data length wherein unnecessary "0's" are removed from the run data and level data of the escape sequence.

Because a pointer position during the current scan of the coding apparatus automatically corresponds to that of the decoding apparatus, bit numbers necessary for expressing the run value corresponded even though additional information is not sent. Furthermore, in the case of the level, because the quantization step size is transmitted to the decoding apparatus for inverse quantization, the bit number necessary for expressing the level can be synchronized by utilizing

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the quantization step size, so that no additional information is needed.

5 Referring to Figure 6, when a variable length coding on a random block is started, a block start signal BST is generated, step 601, and an initial value is loaded on the delay step 602. The initial value corresponds to a maximum potential run value among the potential coded
10 run values.

In the present invention, using the example of an 8 x 8 block, "63" is the initial value. The bit number of the run coded length is established as "6", step 603,
15 and the level coded length is determined by the quantization step size, step 604.

When a symbol, comprising [run, level + code], is input, step 605, it is determined whether the symbol
20 belongs to the regular region at step 606. If the symbol data belongs to the regular region, a regular Huffman code is allocated in accordance with a probability distribution at step 607, and if the data

belongs to the escape region, which is not the regular region, it is coded by the escape sequence at step 608.

5 In other words, because the run data and level data are coded in accordance with the run coded length and level coded length determined in the previous step, the escape sequence can be obtained.

10 Then, the current run data and "1" are subtracted from the current maximum potential run value to thereby calculate a new maximum potential run value at step 609. The run coded length is determined by the new maximum potential run value at step 610. The run coded
15 length is utilized for determining a run data length in the coding of a subsequent symbol.

In this manner, if the coded symbol belongs to the regular region, the symbol is coded by a regular
20 Huffman code for output but if the symbol belongs to the escape region, the symbol is coded by the escape sequence for output.

It is then determined whether the coded data is the end of the block at step 611, and if the data is not the end of the block, the next [run, level + code] symbol is input at step 605. Whereas if the data is the end
5 of the block, a Huffman code corresponding to the end of the block is generated at step 612, and a notice is given that variable length coding on the block has been finished.

10 Thus, the run data and the level data have variable lengths and, consequently, the escape sequence has variable lengths ranging from "7-bits" to "21-bits". Therefore, in some cases, even in the case of a symbol of the regular region, the coded data length can be
15 markedly shortened by coding using the escape data instead of by coding using the Huffman code.

Figure 7 shows a process wherein a variable length coding is performed on one block in accordance with a
20 variable length coding method.

A block start signal is generated at step 701, so that an initial maximum potential run value is loaded at step 702. Then, an initial run coded length of 6-bits (as the 8 x 8 block as presented in the present
5 explanation has a maximum potential runlength of "63") is established at step 703, and according to the quantization step size, the level coded length is determined at step 704.

10 After a symbol is input at step 705, a step wherein it is determined whether the input symbol belongs to the regular region is performed. If this shows that the symbol does not belong to the regular region, the run data and level data are coded according to the run
15 coded length and level coded length determined in the preceding steps to thereby output the escape sequence at step 709. However, if it shows that the symbol belongs to the regular region, the symbol data is coded by the regular Huffman code at step 708 and at the same
20 time, by the escape sequence at step 707. Then, the length of Huffman code and that of escape sequence are compared at step 710, and the shorter of the two is output at steps 711 and 712.

In this manner, either the Huffman code or the escape sequence is output according to the region where the symbol belongs or to the data length to thereafter calculate the maximum potential run value at step 713,
5 so that the run coded length can be determined at step 714.

Then, it is determined whether the coded symbol is an end of the block symbol at step 715 and if the symbol
10 is not the end of the block, the succeeding symbol is input.

If the symbol is the end of block symbol, a Huffman code corresponding to the block end signal is generated
15 at step 716.

Figure 8 is a flow chart for explaining a preferred embodiment of the variable length decoding method in accordance with the present invention.

20

First of all, when decoding is started on one block, a block start signal is generated at step 801, so that an initial maximum potential run value is loaded at step

802. Furthermore, the run coded length is set at
6-bits as an initial value at step 803 and the level
coded length is determined according to the
quantization step size transmitted from the coding
5 apparatus at step 804.

Then, when the coded data is input from the coding
apparatus at step 805, the coded data is checked as to
whether the data is an escape sequence at step 806. If
10 the check result shows that the coded data is an escape
sequence, a decoding process is performed on the escape
sequence at step 807.

In other words, after respective bit numbers for the
15 run data and level data are determined, according to
the run coded length and level data length determined
in the preceding steps, the escape data is classified
to fit to respective data bit numbers, to thereby be
interpreted as the run data and the level data, so that
20 decoding can be realized. Meanwhile, if the
discrimination result shows that the coded data is a
regular Huffman code, the regular Huffman code is
decoded at step 808.

After the decoded symbol data is output at step 809,
the decoded run data and "1" are subtracted from the
current maximum potential run value, so that a new
maximum potential run value can be calculated at step
5 810.

According to the calculated maximum potential run
value, the new run coded length is determined at step
811, and the run coded length is utilized in the
10 decoding process of next coded data.

A determination is made as to whether the currently
decoded symbol is an end of block symbol at step 812,
and if the symbol is not the end of the block symbol, a
15 decoding process, which is the same as the one
explained above, is performed by receiving the coded
data transmitted from the coding apparatus, and if the
symbol is the end of block symbol, a block end signal
is generated, signifying that the decoding process on
20 one block has been finished at step 813.

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As mentioned in the foregoing, a series of coding and decoding methods have been described here in terms of two-dimensional data. However the coding and decoding methods of the present invention equally apply also to
5 one-dimensional data or binary data, so that the length of the escape sequence to be coded can be varied.

CLAIMS

1. A variable length coding method comprising the steps of:

- 5 (a) storing a maximum potential runlength;
- (b) producing a runlength signal, having the number of bits required for the stored maximum potential runlength from an input run data signal;
- (c) producing a new maximum potential runlength by
10 subtracting said run data and a predetermined factor from the current maximum potential runlength;
- (d) storing the new maximum potential runlength; and
- 15 (e) repeating steps (a), (b), (c) and (d).

2. A method according to claim 1, comprising the steps of:

- (f) determining the number of bits required to
20 represent a level signal based on a quantization step signal; and

- (g) producing a level signal having the number of bits determined in step (f).

5 3. A variable length coding method comprising the steps of:

- (a) determining whether an input signal belongs to a first predetermined set or a second predetermined set; and
- (b) if the input signal belongs to the second
10 predetermined set, coding it according to claim 1 or 2.

 4. A method according to claim 3, including the steps of:

- (c) if the input signal belongs to the first
15 predetermined set, coding it according to Huffman coding.

20 5. A method according to claim 4, including the steps of:

- (d) if the input signal belongs to the first set, coding it according to claim 1 or 2; and
- (e) comparing the length of the code produced at step

(c) and (d) and transmitting the coded signal having the shorter length.

5 6. A variable length coding apparatus comprising:
storage means to store a maximum potential runlength;
input means to input a run data signal;
coding means responsive to the bit length of a maximum
potential runlength stored in the storage means to
output the data of the run data signal as a runlength
10 signal having the same number of bits as the stored
maximum runlength; and
means to generate a new potential maximum runlength in
dependence on the input runlength signal and the stored
maximum run length.

15

7. An apparatus according to claim 6, wherein the
storage means comprises a delay.

20 8. An apparatus according to claim 6 or 7, wherein
the means to generate a new potential maximum runlength
comprises a first adder for adding 1 to the input run
data and a second adder for subtracting the output of

the first adder from the stored maximum potential runlength.

5 9. An apparatus according to claim 6, 7 or 8, including means responsive to a quantization step size signal to produce a level signal having a length in bits determined by said quantization step.

10 10. A variable length coded signal decoding method comprising the steps of:

- (a) determining the number of bits of a symbol of an input signal which convey runlength data;
- (b) decoding said run length data;
- (c) decoding level data in said symbol; and
- 15 (d) producing an output signal in dependence on the decoded runlength data and the decoded level data.

20 11. A variable length coded signal decoding method comprising the steps of:

- (a) determining whether an input signal is a signal according to a Huffman code or a signal according to claim 1 or 2; and

(b) decoding the input signal in response to the result of step (a).

12. A variable length coding/decoding method of an
5 image data, the method comprising:
a first step of transforming a sample data to a
transform coefficient of frequency region, quantizing
and scanning the same to a predetermined direction by
dividing the image data into blocks having
10 predetermined numbers of sampling data, so that a
symbol data having a "run" and a "level" as a pair can
be calculated;
a second step of coding the symbol data calculated from
the first process by Huffman code when the data belongs
15 to a regular region, and when the data belongs to an
escape region, coding the "run" in a bit number which
can express the run in a maximum possible way, and
coding and transmitting the "level" by determining the
bit number necessary for an expression in accordance
20 with a quantization step size; and
a third step of discriminating the coded data
transmitted from the second process by a data length of
the run and level to thereafter decode the same.

13. A variable length coding/decoding method of an image data as defined in claim 2, wherein the symbol data having a high occurring frequency is given with a short length of code and the symbol data having a low occurring frequency is allocated with a long length of code when the symbol data is coded by Huffman code.

14. A variable length coding/decoding method of an image data as defined in claim 12, wherein an initial bit number for expressing a maximum potential run becomes N^2-1 in the case of an $N \times N$ block.

15. A variable length coding/decoding method of an image data as defined in claim 12, wherein the second step comprises the steps of:
coding the symbol data by the Huffman code when the symbol data belongs to a regular region and being loaded with a maximum potential run during a start of coding on a block when the symbol data belongs to the escape region;
determining a run coded length which is a bit number necessary for expressing a run data from the maximum

potential run and symbol data run;

coding the run data in accordance with the determined run coded length;

determining a level coded length which is a bit number
5 necessary for a quantized value calculated by a quantization step size; and

coding a level data in accordance with the determined level coded length.

10 16. A variable length coding/decoding method of an image data as defined in claim 12 or claim 15, wherein the bit number for expressing a maximum potential run is calculated by adding 1 to the current symbol data run to thereby subtract from the maximum potential run,
15 so that subsequent bit number can be calculated for expressing a maximum potential run.

17. A variable length coding/decoding method of an image data as defined in claim 12 or claim 15, wherein
20 the level is coded by dividing the maximum potential value of a transform coefficient by quantization step size to thereby calculate the numbers of quantized value having mutually different levels and determining

by the level coded length the bit numbers necessary for expressing the maximum values of numbers of quantized values.

5 18. A variable length coding/decoding method of an image data as defined in claim 12, wherein the third step comprises the steps of:

being loaded with maximum potential run when a decoding is started on a block;

10 determining the run coded length which is the bit number necessary for expressing the run data from the maximum potential run and the run of symbol data;

decoding the run data in accordance with the determined run coded length;

15 determining the level coded length which is the bit number necessary for expressing the quantized value calculated from the quantization step size; and

decoding the level data in accordance with the determined level coded length.

20

19. A variable length coding/decoding method of an image data as defined in claim 18, wherein the run decoded length calculates a subsequent bit number for

expressing the maximum potential run by adding 1 to the run of current symbol data to thereby subtract from the maximum potential run.

5 20. A variable length coding/decoding method of an image data as defined in claim 18, wherein the level coded length is a bit number necessary for expressing the quantized value calculated from the quantization step size.

10

21. A variable length coding/decoding method of an image data, the method comprising: a first step of transforming a sample data to a transform coefficient of frequency region, quantizing and scanning the same to a predetermined direction by dividing the image data
15 into blocks having predetermined numbers of sampling data, so that a symbol data having a "run" and a "level" as a pair can be calculated; a second step of coding the symbol data calculated from the first
20 process by Huffman code and escape sequence when the data belongs to a regular region, and outputting by the Huffman code when the escape sequence is larger than the Huffman code and coding the run by the bit

number for expressing the maximum potential run when the escape sequence is smaller than the Huffman code or belongs to the escape region, and coding and transmitting the "level" by determining the bit number
5 necessary for expression in accordance with a quantization step size; and a third step of discriminating the coded data transmitted from the second process by the data length of the run and level to thereafter decode the same.

10

22. A variable length coding/decoding method of an image data as defined in claim 21, wherein the symbol data having a high occurring frequency is given with a short length of code and the symbol data having a low
15 occurring frequency is allocated with a long length of code when the symbol data is coded by the Huffman code.

23. A variable length coding/decoding method of an image data as defined in claim 21, wherein an initial
20 bit number for expressing a maximum potential run becomes N^2-1 in the case of an $N \times N$ block.

24. A variable length coding/decoding method of an image data as defined in claim 21, wherein the second step comprises the steps of coding the symbol data calculated from the first process by Huffman code and escape sequence when the data belongs to a regular region, and outputting by the Huffman code when the escape sequence is larger than the Huffman code and being loaded with a maximum potential run when a coding on a block is started if the escape sequence is smaller than the Huffman code or belongs to escape region; determining the run coded length which is the bit number necessary for expressing the run data from the maximum potential run and the run of symbol data; coding a run data in accordance with the determined run coded length; determining the level coded length which is the bit number necessary for expressing the quantized value calculated by the quantization step size; and coding a level data in accordance with the determined level coded length.

25. A variable length coding/decoding method of an image data as defined in claim 21 or claim 24, wherein the bit number necessary for expressing the maximum potential run calculates subsequent bit numbers for expressing the maximum potential run by adding 1 to a run of current symbol data to thereby subtract from the maximum potential run.

26. A variable length coding/decoding method of an image data as defined in claim 21 or claim 24, wherein the level is coded by dividing the maximum potential value of the transform coefficient by a quantization step size to thereby calculate the numbers of quantized value having mutually different levels and determining by level coded length the bit numbers necessary for expressing the maximum values of numbers of quantized values.

27. A variable length coding/decoding method as defined in claim 21, wherein the third step comprises the steps of:

being loaded with maximum potential run where a decoding is started on a block;

determining the run coded length which is the bit
number necessary for expressing the run data from the
maximum potential run and the run of symbol data;
decoding the run data in accordance with the determined
5 run coded length;
determining the level coded length which is the bit
number necessary for expressing the quantized value
calculated from the quantization step size; and
decoding the level data in accordance with the
10 determined level coded length.

28. A variable length coding/decoding method of an
image data as defined in claim 27, wherein a run
decoded length calculates subsequent bit numbers for
15 expressing the maximum potential run by adding 1 to a
run of current symbol data to thereby subtract from the
maximum potential run.

29. A variable length coding/decoding method of an
20 image data as defined in claim 27, wherein the level
coded length is a bit number necessary for expressing
the quantized value calculated from the quantization
step size.

30. A variable length coding/decoding apparatus of an image data, the apparatus comprising:
- first means for dividing an image data into blocks having predetermined numbers of sampling data, transforming the sampling data to a transform coefficient of frequency region, quantizing and scanning the same in a predetermined direction and calculating a symbol data having a "run" and a "level" as one pair;
- second means for coding the symbol data calculated from the first means by Huffman code when the data belongs to a regular region;
- third means for coding the "run" in bit numbers which can express the run in a maximum possible way when the symbol data calculated from the first means belongs to an escape region, and coding and transmitting the "level" by determining the bit numbers necessary for an expression in accordance with a quantization step size; and
- fourth means for discriminating the coded data transmitted from the third means by a data length of the run and level to thereafter decode the same.

31. A variable length coding/decoding apparatus of an image data as defined in claim 30, wherein the second means allocates a short-lengthened code to a symbol data having a high occurring frequency and
5 allocates a long code to a symbol data having a low occurring frequency.

32. A variable length coding/decoding apparatus of an image data as defined in claim 30, wherein an
10 initial bit number for expressing a maximum potential run becomes N^2-1 in the case of a $N \times N$ block.

33. A variable length coding/decoding apparatus of a an image data as defined in claim 30, wherein the third
15 means comprises a delayer which is loaded with a maximum potential run to thereby be stored when a coding on a block is started and subtracts a run added with 1 from the maximum potential run to thereby change the subtracted run to the maximum potential run;
20 a run coded length determining unit for determining a run coded length which is the bit number necessary for expressing a run data in accordance with the maximum

potential run value supplied from the delayer;
a run coding unit for coding the run data in accordance
with the run coded length determined by the run coded
length determining unit;

5 a level coded length determining unit for determining
a level coded length which is the bit number necessary
for expressing quantized value calculated by a
quantization step size; and
a level coded unit for coding the level data in
10 accordance with the level coded length determined by
the level coded length determining unit.

34. A variable length coding method substantially as
hereinbefore described with reference to Figures 5, 6
15 and 7 of the accompanying drawings.

35. A variable length coding apparatus substantially
as hereinbefore described with reference to Figures 5,
6 and 7 of the accompanying drawings.

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36. A variable length coded signal decoding method
substantially as hereinbefore described with reference
Figure 8 of the accompanying drawings.

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Relevant Technical fields

- (i) UK CI (Edition L) H4F (FRR, FRD)
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- (ii) Int CI (Edition 5) H04N (1/41, 7/137)
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Databases (see over)

(i) UK Patent Office

(ii)

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Documents considered relevant following a search in respect of claims 1, 6

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
AE	GB 2260458 (SONY) page 5, lines 4 to 8	1, 6

Category	Identity of document and relevant passages	Relevant to claim(s)

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